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COMPARATIVE ANALYSIS OF BLACK-SCHOLES AND GARCH MODEL IN RUPIAH AND AMERICAN DOLLAR WITH SHORT STRANGLE STRATEGY FROM 2009 TO 2018

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ABSTRACT

Foreign exchange transaction remains the most liquid trade in the world (Settlements, 2019). This paper examined the exchange rate of the US Dollar against Indonesian Rupiah at which volatility recorded the highest average of 1.98% and the lowest of 1.98% between 2009 and 2018. It shows that the existence of uncertainty or risk for economic actors. According to economists, the thing to protect the value of assets is by using available derivative products, The Option. The first model used for forecasting and determining the Option values is the Black-Scholes Model that uses historical volatility and some GARCH model to determine volatility. In this study, the object of the exchange rate of the US Dollar with Rupiah was comparing to two models using the average mean square error, and see how small the error results obtained. The results of the comparison of those two models found that during a month, the Black Scholes model had smaller errors for call and put values with a percentage of profits using a short strangle strategy was 83.75%. In contrast, over 2 months, the GARCH model showed better for call and put values with a profit percentage was 71.62%. Finally, the Black-Scholes model got a way better for call and put supplies with a percentage of the profit of 72.04% within 3 months.

Keywords: *black-scholes, exchange rate, option derivative, short strangle*

INTRODUCTION

Bank Indonesia issued policy No.18 / 18 / PBI / 2016 concerning foreign exchange against Rupiah between banks and domestic parties which shows the importance of hedging for businesses that are prevailing in Indonesia (Indonesia, Surat Edaran Bank Indonesia Nomor 18/34/DPPK tentang Transaksi Valuta Asing terhadap Rupiah antara Bank dengan Pihak Domestik, 2019)

Based on the data on the movement of the Rupiah against the US Dollar from January 2014 to December 2018 presented on figure 1, it indicated that fluctuations in the Rupiah against the US Dollar experienced the highest weakening of 2.36% on December 16, 2014, and experienced the highest strengthening of 2.23% on October 7, 2015.

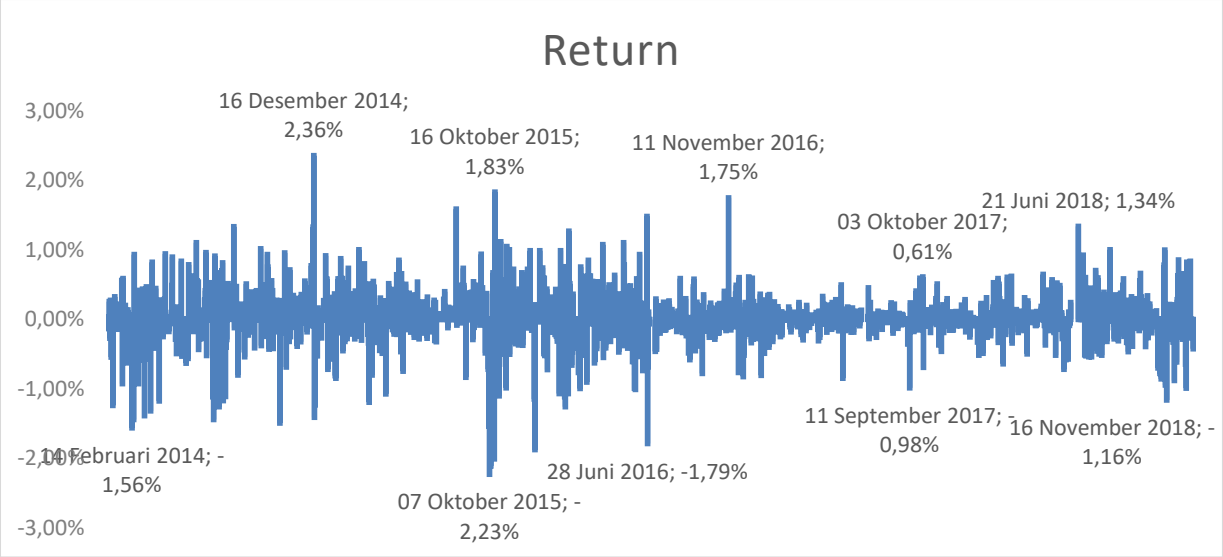

Figure 1 Daily Return for 5 years

Furthermore, if you analyze further in the past 10 years, based on Table 1 it can be seen that the lowest daily return was -2.81% in 2011 and the largest daily return was 3.04% in 2009. The highest daily return range occurred in 2009 receiving 5.81%. The table also demonstrates that the highest average return for 10 years was 1.98% and the lowest average was -1.94%.

Table 1 Daily Return for 10 years

Daily Return						
Date	Highest	percentage	Date	Lowest	percentage	range
2/2/2009	0.0304	3.04	24/03/2009	-0.0277	-2.77	5.81
6/5/2010	0.0168	1.68	10/5/2010	-0.0185	-1.85	3.53
26/9/2011	0.0275	2.75	23/9/2011	-0.0281	-2.81	5.56
4/6/2012	0.0139	1.39	1/6/2012	-0.0242	-2.42	3.81
11/9/2013	0.0231	2.31	19/9/2013	-0.0186	-1.86	4.17
16/12/2014	0.0299	2.99	14/2/2014	-0.0155	-1.55	4.54
16/10/2015	0.0186	1.86	7/10/2015	-0.0221	-2.21	4.07
11/11/2016	0.0177	1.77	28/6/2016	-0.0177	-1.77	3.54
3/10/2017	0.0062	0.62	11/9/2017	-0.0097	-0.97	1.59
21/6/2018	0.0135	1.35	16/11/2018	-0.0115	-1.15	2.5
Average	0.01976	1.98		-0.0194	-1.936	3.912

However, the data indicate that there were uncertainties (risks) faced by investors. In the investment world, there is one instrument that operates as a hedging tool, known as options. An option is the right to sell and buy assets in the future at an agreed price, time and amount.

Determination of the value of the option contract carried out by the agent in this case the investment manager aims to generate profits for investors (principals). An agency relationship is a contract in which one or more people (principals) govern another person (broker) to perform a service on behalf of the principal and authorize the agent to make the best decision

for the principal. If both parties have the same goal to maximize the value of a company, so it is believed that the agent will act in a manner consistent with the principal's interests (Messier, 2008).

Hendrawan (2017) conducted research to demonstrate whether the long straddle options strategy can address the phenomenon of volatility shocks from 1998 to 2016 using index objects. The results of the study demonstrate that the long straddle options strategy can answer the phenomenon of volatility shocks. If it is pinned down during years that have high volatility and an economic crisis occurs, the possibility of volatility shocks leading to a decrease in the index is much greater. In 1998 volatility shocks to the index decreased by 58.24%, while in 2008 volatility shocks led to a decrement in the index of 76.47%.

Bejol & Livingstone (2018) study on currency swaps shows that the effectiveness of swaps depended on the historical framework of the exchange rate. If foreign currencies depreciated against domestic ones, cash flow hedges return from property investment proved to be superior to unprotected strategies.

Another study is from Hendrawan (2017) stated that forward contracts were better than forward option contracts and do not use No Hedging in managing the risk of currency pressures.

Mathoera (2016) studied several methods of estimating the volatility of index options. The author researched the Nifty 50 index and the VIX index over 3 years (1 January 2011 - 31 December 2014). GARCH is better than Black Scholes.

In another study, (Hendrawan & Sasmito, 2021) examined models of option prices with the WIG20 index object. Kaminski compared 3 well-known models, namely Black Scholes, GARCH and the Duan (Duan Approach) approach. He revealed that the Black Scholes Model with the GARCH volatility approach was the best among other models, this can be determined from the value of the Mean Absolute Pricing Errors (MAPE) & the smallest Median Absolute Pricing Errors (MdAPE).

Lastly, (Syahputri et al., 2022) found that multilateral banks used currency swaps, currency forwards, currency options and currency futures to hedge exchange rate risks.

Based on the data and those previous studies, this study aimed to analyze the application of option theory with strangle strategy on Indonesian Rupiah against the US Dollar between 2009 and 2018 by using the Black-Scholes method with Historical volatility and GARCH (Generalized Autoregressive Conditional Heteroscedasticity) volatility.

METHOD

This research used quantitative methods with comparative and descriptive approaches. The study was conducted with the aim that researchers know the comparison between the application of the Black Scholes and GARCH models on the exchange rate of the Rupiah against the US Dollar. This study used time-series data as a time frame and used a sample of the middle exchange rate data of the Rupiah against the US Dollar from 2009 to 2018.

RESULTS AND DISCUSSION

Volatility calculations were performed using historical volatility (with 1,2 and 3 months of historical data) and GARCH data from the past 10 years. The following figure illustrate the result:

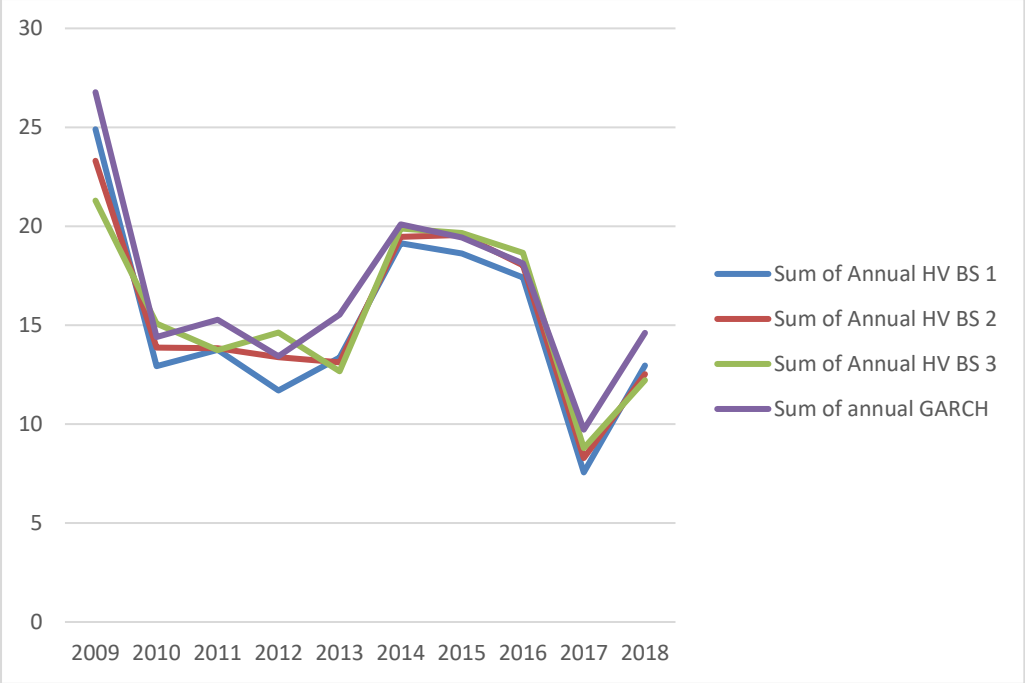

Figure 2 Comparison of Historical Volatility and GARCH

From the figure presented previously, it can be determined that the historical volatility values tend to be lower than the GARCH volatility for three different periods (1, 2 and 3 months).

Model Testing Results

Testing with a maturity (T) of 1 month

Model testing was done by comparing the two models seen from the percentage value of the square root of the error (AMSE) where a smaller value indicated the model was better. During the 10 years, sample data gathered were 2430 in total. With the maturity of 1 month, the following AMSE values are obtained as presented in Table 2:

Table 2 Historical and GARCH volatility Comparison per year (1 month)

Model	Year	AMSE		Model	Year	AMSE	
		call	put			call	put
Historical 1 month	2009	0.376%	124.284%	GARCH 1 month	2009	0.652%	137.158%
	2010	0.376%	0.545%		2010	0.370%	0.533%
	2011	0.356%	0.238%		2011	0.353%	0.217%
	2012	0.365%	1.323%		2012	0.364%	1.232%
	2013	0.379%	0.400%		2013	0.436%	0.371%
	2014	0.326%	1.261%		2014	0.313%	1.566%
	2015	10.032%	0.253%		2015	19.945%	0.252%
	2016	0.354%	2.719%		2016	0.354%	2.853%
	2017	0.395%	0.295%		2017	0.392%	0.266%
	2018	0.372%	57.311%		2018	0.366%	60.427%

Table 2 indicates that in the calculation per year the GARCH model had the lowest AMSE call and put values in 2011, 2012 and 2017.

Table 3 Historical and GARCH volatility Comparison 10 years (1 month)

Model	AMSE	
	call	put
BS 1 month	0.1341%	1.7833%
GARCH 1 month	0.2368%	1.9346%

Table 3 shows the accumulation of the 10-years AMSE value. It is seen that historical volatility had the lowest AMSE call and put value.

Testing with a maturity (T) 2 months

Table 4 Historical and GARCH volatility Comparison per year (2 months)

Model	Year	AMSE		Model	Year	AMSE	
		call	put			call	put
BS 2 months	2009	0.254%	26.469%	GARCH 2 months	2009	0.262%	19.946%
	2010	0.346%	311.844%		2010	0.343%	333.401%
	2011	22.474%	1780.946%		2011	1.930%	4292.913%
	2012	0.366%	0.246%		2012	0.362%	0.243%
	2013	0.691%	0.357%		2013	0.841%	0.304%
	2014	11.562%	0.271%		2014	2.674%	0.333%
	2015	174.462%	12.905%		2015	125.733%	7.775%
	2016	3.280%	2.584%		2016	3.682%	3.720%
	2017	0.384%	0.246%		2017	0.372%	0.224%
	2018	2.298%	24.226%		2018	6.988%	43.302%

Table 4 indicates that in the calculation per year, the GARCH model had the lowest AMSE call and put values in 2012, 2015 and 2017. For historical volatility, the lowest AMSE call and put values occurred in 2016 and 2018.

Table 5 Historical and GARCH volatility Comparison 10 years (2 months)

Model	AMSE	
	call	put
BS 2 months	2.1981%	22.0325%
GARCH 2 months	1.4554%	48.0019%

Table 5 shows the accumulation of AMSE of 10-year values, GARCH volatility had the lowest AMSE call value and historical volatility had the lowest AMSE put value.

Testing with a maturity (T) of 3 months

Table 6 Historical and GARCH volatility Comparison per year (3 months)

Model	Year	AMSE		Model	Year	AMSE	
		call	put			call	put
BS 3 months	2009	0.179%	42.288%	GARCH 3 months	2009	0.194%	33.847%
	2010	0.629%	567.354%		2010	0.395%	487.872%
	2011	31.313%	1588.562%		2011	6.487%	5967.232%
	2012	6.251%	0.202%		2012	0.574%	0.224%
	2013	0.953%	0.388%		2013	1.853%	0.312%
	2014	25.858%	0.288%		2014	9.947%	0.404%
	2015	654.085%	32.838%		2015	489.107%	11.039%
	2016	6.559%	3.711%		2016	9.340%	5.628%
	2017	0.360%	0.210%		2017	0.343%	0.194%
	2018	2.298%	24.226%		2018	19.377%	67.238%

Table 6 shows that in the calculation per year the GARCH model had the lowest AMSE call and put values in 2010, 2015 and 2017. Historical volatility has the lowest AMSE call and put values in 2016 and 2018.

Table 7 Historical and GARCH volatility Comparison 10 years (3 months)

Model	AMSE	
	call	put
BS 3 months	2.1981%	22.0325%
GARCH 3 months	5.5116%	67.6339%

Table 7 shows the accumulation of 10-year AMSE values. Historical volatility has the lowest AMSE call and put value.

DISCUSSION

The result of this study for single-month maturity shows that the Black-Scholes model had a smaller error value than the GARCH model in valuing call and put option prices. For a maturity of 2 months, the Black-Scholes model was more proficient to determine the value of put options and the GARCH model is better at determining the value of call options(Nurlia & Juwari, 2020). Furthermore, for a maturity of 3 months, the Black-Scholes model was more proficient in determining the value of the call and put option contracts. The percentage of errors increases with the maturity of the option contract. The measure of data in the profit area was greater in the model with a maturity of 1 month.

The outcomes of this study reinforce the results of a study conducted by (Mathoera, 2016), His study found that Black Scholes had a smaller Square Root Error (RMSE) value in OTM (On the Money) and ITM (In the Money) conditions, at ATM (At the Money) conditions GARCH had a better Root Square Error value than Black Scholes.

Kaminski's study (2013) revealed a similar finding in which the Black Scholes model is better than the GARCH model based on smaller MAPE values both at put options and call options.

CONCLUSION

It can be concluded that. The exchange rate of Indonesian Rupiah to the US Dollar with a maturity period of 1 month using the short strangle strategy showed that the Black Scholes model with historical volatility was lower than the average percentage error square root (AMSE) compared to the GARCH model.

The exchange rate of Rupiah for US Dollar with a maturity period of 2 months using the short strangle strategy showed that the Black Scholes model with lower historical volatility had an average percentage error square root (AMSE) for the value of the put contract, while the GARCH model had a better AMSE value for the value of the call contract.

Finally, the Rupiah exchange rate against the US Dollar with a maturity period of 3 months using the short strangle strategy showed that the Black-Scholes model with historical volatility was lower than the average percentage error square root (AMSE) compared to the GARCH model.

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